Experiment 3

B. Damped Oscillations

Read the introductory paragraphs to this section in the lab manual. When you reach the part that says *Follow these steps*, ignore them, and follow these instead:

Follow these steps:

Collect Data

1. If data is left on the computer from the previous students, close the file without saving it. On the desktop, open the file call "Spring Oscillations".
2. With the apparatus set up as in the figure in the manual, remove the disk magnet- first you will observe what un-damped oscillations look like.
3. With the mass stationary, *Zero* the probe by clicking the 0 icon along the top. Displace the mass by 5-10cm from its rest position and release, soon afterwards start the data collection by clicking on 

. You can scale the plot automatically by clicking the *Autoscale*  icon.
4. When finished, save the un-damped oscillation trace by selecting the menu Experiment-> Store Latest Run.
5. Now, attached the disk magnet to the side of the mass closest to the aluminum support beam. Repeat step 3 to collect the data for the damped oscillations.
6. When finished, notice as you move the mouse over the data, the point on the graph of the cursor is displayed in the bottom left corner in the format (time, position). Hover the cursor over the peaks of the damped oscillations and record a table of points for every third peak, (up to a maximum of 8 data points).

Analyze Data

1. You are going to now attempt to determine the time constant of the decay using two different methods. The time constant tells you how long it takes for the amplitude of the oscillations to decrease by a factor of 1/e.
2. First, the software can fit the expected shape of the oscillations, and you can extract the time constant from the parameters of the fit. The expected shape is a sine wave oscillation with exponential damping. Mathematically, it can be represented by:

$$Position = A_o e^{-t/\tau}\cos(\omega t + \varphi) + offset \qquad \text{(equation 1)}$$

   Click on the *Curve Fit*  icon. Be sure to select Latest Run, to ensure you fit the damped oscillation data. Select the function "Damped Oscillations" from the menu, and click *Try Fit*. Note the form of the equation in the software is A*exp(-t/B)*cos(C*t+D)+E. The software will attempt to fit the data to requested lineshape, this takes about a minute. When it is finished click OK,

and after a few more seconds, the fit line will appear on the plot, along with the fit parameters. Determine which fit parameter corresponds to τ . Print off two copies, one for you and one for your partner.

3. You will also determine τ manually. Create another column in your table of data which you recorded in part 6 of Collect Data. In this third column, compute the natural logarithm of the position. i.e. *ln(position)*. Note if you take the *ln* of both sides equation 1 you get:

$$\ln(Position) \propto -t/\tau$$

   Comparing this to an equation for a straight line *y=mt*, you can see the slope m is *-1/*τ.
4. Plot on linear graph paper *ln(position)* vs *time*. Determine the slope, and from the slope determine τ. Estimate the uncertainty in the slope by looking at the scatter of the data points off of your line of best fit. Imagine how the graph would have looked if you didn't take the natural logarithm. It would be more difficult to make your line of best fit. This was a clever way of getting a straight line graph from non-linear data.
5. Compare the two methods of determining τ. Do they agree?

Questions

1. Does the time for one oscillation (the period) changing during the damped oscillations?
2. Give at least one example where oscillations occur and where it would desirable to damp them.
3. What would happen if rather than magnetic braking, some form of resistive braking was used- for example if the mass itself (without magnet) was rubbing on the aluminum support beam? Would you expect an exponential decay?
4. Is Aluminum magnetic?